This fauna belongs to the upper portion of the Lower Cambrian, and it is essentially the same as that found above the tunnel at Mt. Stephen, B. C., and also found more or less all along the Cordilleran system down into southern Nevada.

The stratigraphy of the section is as follows:

Lower Cambrian	Chocolate-brown shales —*olenellus fauna*...	50 + feet
	fine-grained quartz conglomerate	300 + feet
	coarse conglomerate...	6 feet
	disconformity	
Precambrian Beltian	purple and green mud cracked siliceous metargillites (Siyeh)..	300 ± feet
	Purcell lava—amygdaloidal basalt.....	100 feet
	purple and green mud cracked siliceous metargillite and siliceous limestones.....(Siyeh formation)	1,000 + feet

In the Cranbrook area the characteristics of the disconformity between the Cambrian and Precambrian are:

1. The thickness of the sediments between the Purcell lava and the basal conglomerate of the Lower Cambrian varies from a few feet to three hundred feet, showing evidence of an unconformity.

2. The upper surface of the Precambrian does not show any evidence of weathering before the deposition of the Lower Cambrian.

3. The Precambrian and Cambrian strata correspond in dip and strike. At no place were discordant relationships observed.

4. The metargillites of the Precambrian are more highly metamorphosed than those of the Cambrian.

5. The contrast in lithology between the Precambrian and Cambrian formations is very marked. Mud cracked and ripple marked purple and green metargillites are characteristic of the Precambrian while the Lower Cambrian rocks are white quartzose conglomerates succeeded by grey and chocolate-brown shales.

6. The basal conglomerates of the Cambrian contain rounded fragments of the underlying siliceous argillites.

A full detailed statement concerning the stratigraphical relationships of the Precambrian and the Cambrian over a wide area is now in course of preparation to be published by the Geological Survey of Canada.

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HOWARDULA BENIGNA; A NEMA PARASITE OF THE CUCUMBER-BEETLE

Howardula[1] Cobb. Characters of *Aphelenchus* Bastian, 1865, but without œsophageal bulb and with a non-bulbous onchium and much reflexed ovary. "Female" finally a flaccid, cylindroid sack, without distinct alimentary canal, and otherwise much deteriorated. Syngonic; male unknown. *Howardula* may be related to *Bradynema* zur Strassen, 1892, but the latter has no onchium and even lacks a mouth opening.

1.1	(?)5.	(?)	95 98.	(?) 99.	3.5–5. mm
2.5	4.0	4.7	4.1	1.9	

Howardula benigna Cobb. Anus none or vestigial; vulva sometimes terminal; uterus nearly filling the body-cavity, posteriorly packed with larvæ and anteriorly with segmenting eggs, near the head in the vicinity of the small spermathecum narrowed and reflexed to the middle of the body, whence the narrow ovary turns forward and ends blind near the lead; onchium usually very obscure but the minute mouth opening still persisting. Inert, viviparous, usually all of the same stage of development in any individual host-insect, each when mature containing about two thousand embryos and segmenting eggs; the larvæ, apparently always all of one kind, sometimes ten to twenty thousand of them, proceeding from the mother nemas into the body-cavity, and into the sexual ap-

[1] Named for my distinguished friend Dr. L. O. Howard, chief of the U. S. Bureau of Entomology, president and past permanent secretary of the American Association for the Advancement of Science.

paratus, of the host, and so becoming deposited with the eggs of the latter.

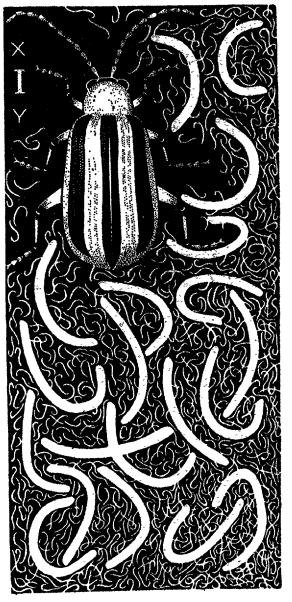

Fig. 1. Shows relative volume of beetle and parasites. The line XY shows the actual length of the beetle.

The newborn larvæ measure as follows:

3.4 (?)12.	..... 28.	—91.	(?)94.8		
2.3	3.2	3.7	2.8	2.2	0.54 mm

Anus none or vestigial; tail conoid, straight, broadly rounded or subtruncate at the terminus. After deposition along with the beetle eggs, the young nemas moult with little increase in size, some of them then boring their way into the body-cavity of even very young larvæ of both sexes of the beetle, sometimes to the number of thirty but more often five or six. The following are the dimensions and other details of these young but already spermatized individuals, as found both in the soil and in very young beetle-larvæ, which in the body-cavity of the host reach the above, seven to ten times longer, mature form:

2.	16. ..... (?)24.	75 — 95.	(?) 97.		
2.	4.	5.	4.	2.6	0.5 mm

Habitat: Common in the body-cavity (abdomen, thorax and even head) of *Diabrotica vittata, trivittata,* and *12-punctata,* especially the former, infesting the two sexes about equally.

My attention was called to this nema by Mr. W. V. Balduf, Assistant Entomologist, Ohio Agricultural Experiment Station, Marietta, Ohio, where he discovered the larvæ in

Fig. 2. Cucumber-beetle egg and the charge of nemas deposited with it.

the course of experiments on *Diabrotica.* Owing to the economic aspect of the subject, beetles sent me by Mr. Balduf were exhibited, dissected, at the Washington Helminthological Society's meeting, March 17, 1921. Examination revealed the adult female form, which is so flaccid and otherwise deceptive as to cause it rather easily to be confused with the internal organs of the host by one not versed in both insect and nema anatomy.

Aided by Dr. F. H. Chittenden and colleagues of the Federal Bureau of Entomology, and by others, the geographical distribution of the nema was studied with results shown on the accompanying map, which indicates that the distribution in 1921 is probably nearly coextensive with that of the main hosts, *Diabrotica vittata* Fab. and *trivittata* Mann. The nematism is often high and affects on the average about 20 per cent. (0 per cent.—70 per cent.) of the insects. Beetles from a locality where they are not nematized are larger and more vigorous. Thus twenty-five

beetles from an uninfested lot were much larger and averaged seventy per cent. heavier than a similarly chosen twenty-five from a fifty per cent. nematized lot. Anatomical evidence shows the infested female beetles to be less fertile than the non-infested, doubt as to

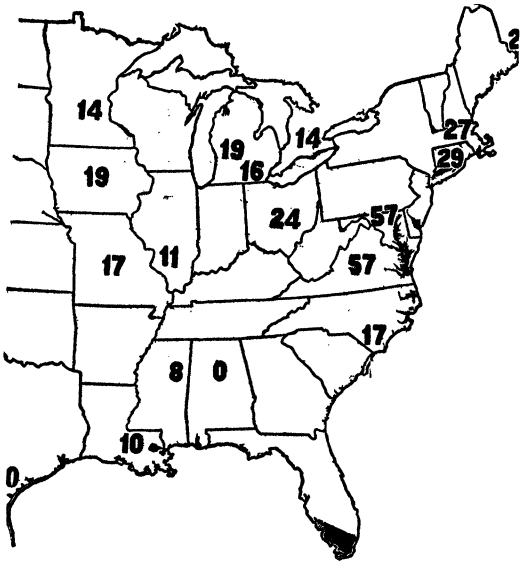

FIG. 3. The map-figures give the percentage of beetles found infested by *Howardula*. The figures for different localities a few miles apart in any given region usually were in substantial agreement. Where the percentage of infestation was highest, the nematism was highest, and vice versa. The presence of the nema does not exclude other internal parasites, such as other insects and gregarines. About 1,500 *D. vittata* were examined. Below are addresses of those who kindly contributed insects for examination.

Balduf, W. V., Marietta, O.
Cobb, Dr. F., Ann Arbor, Mich.
Cobb, V., Whitman, Mass.
Chapin, E. A., Falls Church, Va.
Fenton, E. A., Ames, Iowa.
Flint, W. P., Urbana, Ill.
Gentner, L., Lansing, Mich.
Hall, Dr. M. C., Chevy Chase, Md.
Harned, R. W., Agr. College, Miss.
Haseman, L., Columbia, Mo.
High, M. M., Kingsville, Tex.
Kelsall, A., Annapolis Royal, N. S.
Raps, E. M., Oakton, Va.
Riley, Wm. A., St. Paul, Minn.
Ross, W. A., Vineland Sta., Ont.
Smith, C. E., Baton Rouge, La.
Thomas, W. A., Chadbourn, N. C.
Walters, M. J., New London, Ct.
Watson, J. R., Birmingham, Ala.

diminished fecundity vanishing where the female host harbors a dozen or more adult nemas. In such cases the mere relative volume of the parasites is convincing evidence of handicap. See Fig. 1. Mr. Balduf in a letter speaks of beetles, many of which "died of nemas." I have no rigid proof of such deaths, but believe them very probable and at times numerous.

In none of the numerous lots of beetles examined was the rate of infestation by any other zoo-parasite as high as by *Howardula*, with the single exception of a forty-three per cent. dipterous infestation; but no note was made of degrees of phyto-infestation (cucumber-wilt organism, etc.).

As many as thirteen thousand nema larvæ, by count, have been removed from the body-cavity of a single *Diabrotica vittata*, and no doubt the number may go much higher. On several occasions twenty or more adult How-

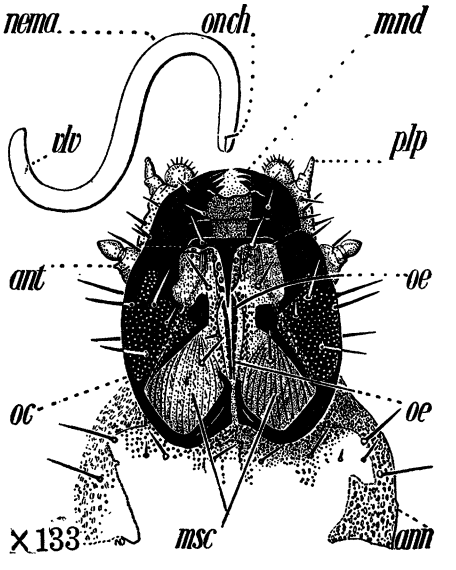

FIG. 4. Head of very young cucumber-beetle larva and of young *Howardula* at the time of its entrance. The mandibles of the grub, *mnd*, would seem to be impassable to the nema.

ardulas have been taken from a single beetle. Theoretically these should produce some forty thousand larvæ or more. The older female

beetles, when nematized, deposit from a few to upwards of fifty of the nema larvæ with each egg. See Fig. 2. These soon mature on the eggs or in the soil (where they can live several weeks), moult, develop a more perfect spear, and by its aid begin to make their way into the body-cavity of the beetle grubs soon after the latter hatch out. That it is rather improbable the nemas enter the host by way of the mouth and alimentary canal is illustrated in Fig. 4. The active young beetle larvæ are armed with sharp-toothed, well developed mandibles. That the tender young nemas could pass so relatively small a throat and mouth, armed as the latter is, one hesitates to believe.

In plant-infesting triplonchs I have shown the development of the so-called salivary glands to be greatest in species noted for their efficiency in destroying the tissues of the host, and suggested that these glands aid in dissolving the host tissues and thus supplement the mechanical action of the spear or onchium, which therefore should then act also as a spewing channel. In light of this, it may not be without significance that the salivary glands of *Howardula benigna* appear better developed than in some of its nearest known relatives. Conceivably this secretion is also antiseptic. Nemas of very many kinds make their way through the tissues of their hosts without causing fatal infections. The existence of an antiseptic nema secretion or excretion might explain this. In the case of *Diabrotica,* there is no known trace left of the relatively large breach made by the parasite, a benignant result perhaps facilitated by the parasite itself in the way indicated.

The present investigations suggest how far we are from appreciating the abundance and importance of insect parasites and how backward in attempting their control. *Howardula* is, beyond any reasonable question, ages old, for on no other supposition can the remarkable relationship of host and parasite be explained. It is only one of a considerable number of parasites of the same destructive insect that have much to do with the welfare of the host. Intelligently increasing the incidence of the parasites decreases the ravages of the host. When we come to understand these relationships, these "balances" between host and parasite, doubtless we can do much toward inclining the "balance" in our favor. We hear more or less of organisms introduced to new areas without their enemies and parasites, and in consequence becoming frightful pests, and we have, very painfully and slowly it seems to some of us, learned that searching for and introducing these same enemies and parasites affords relief. Marked successes of this kind at least place it beyond doubt that this portion of the field of economic parasitology will be carefully explored. But there is another very important part of the field of which we hear little if anything, and that is the comprehension and watchful control of what may be termed indigenous or long-established "balances."

The cucumber-beetle affords good enough example of these latter to justify an appeal, on the basis of it, to economic biologists to scrutinize more carefully the ever changing "balances" between pests and their parasites and other enemies, *including pests of long standing,* with a view to keeping the "balance" always inclined in our favor. I believe any well trained, experienced and thoughtful biologist will agree that such a course is bound finally to result in notable economies. A case in point is the existence of localities, among those here tested, in which the total zoo-parasitic infestation of the beetles reached only about two per cent. At the same time not very far away there was a nema infestation exceeding fifty per cent. and a dipterous infestation exceeding forty per cent. The investigation showed that the transference by post of these two parasites from the highly infested areas to the low or non-infested areas was easily feasible at small cost. Posted in a ventilated box with a few cucurbit leaves the infested beetles undergo a two to four days' journey; set loose at night they survive without apparent injury.

N. A. Cobb
United States Department of Agriculture